

## **FINAL REPORT**

### **Billfish Interactions, Livelihoods, and Linkages for Fisheries sustainability in the Western Indian Ocean (BILLFISH-WIO)**

<https://billfishwio.com/>

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## Acknowledgements

The project team recognizes the efforts of the sport, recreational and artisanal fishing communities across the Western Indian Ocean (WIO) region, who have voluntarily collected and reported historical and current fisheries data. This work was inspired by the lived experiences and interactions with many stakeholders who continue to challenge us to want to learn about the dynamics of these magnificent, highly migratory species.

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## Executive Summary

The comprehensive BILLFISH-WIO project has continued to spearhead billfish research spanning across several countries in the Western Indian Ocean (WIO) to address specific objectives including (i) assessing the historical and present status of billfish species; (ii) evaluating the socio-economic contribution and governance of billfish; (iii) evaluating the genetic structure of key species; and (iv) determining the spatial and temporal distribution of billfish species.

Since its inception, BILLFISH-WIO has published and submitted several papers that have continued to accelerate our dynamic understanding of these species, necessitating the need for national and regional attention on their sustainable management. These papers have explored critical topics in billfish fisheries, for example, fisheries conflicts among billfish resource users, the challenges of sustainable development and management of billfish fisheries and the historical and current data and knowledge of the species regionally.

We upscaled our efforts in enhancing the research and leadership capacity of emerging scientists, collaborating institutions, and partnering community groups regionally through working with over 20 collaborators and diverse institutions including 4 Ph.D. (one graduated), 6 MSc and 2 BSc students (recently graduated). Our collaboration provided the opportunity to work with early career researchers from Somalia through Project Kalluun, an initiative of One Earth Future -Secure Fisheries. The active involvement of students who are mostly early career scientists is a critical step towards the development of expertise to promote billfish research in the WIO.

We are proud to note that BILLFISH-WIO has been successful in achieving its goal and objectives. We synthesize the extensive outputs and outcomes ranging from scientific and grey literature, science communication, multi-sector partnerships and engagement at national, regional and global scale. A key success of the project has also been on obtaining additional funding resulting in expansion of the project to Comoros, Mauritius, and Seychelles.

The outputs and outcomes continue to address key areas under WIOMSA-MASMA priority research themes, including socio-ecological approaches for the sustainable use of marine living resources, contribution to food security and safety, understanding biodiversity and its change, and impacts and mitigation of the risks of climate change.

Our work provides a much-needed first-time region-wide survey of artisanal and recreational fisheries as well as overarching lessons learnt that are critical for future work. For example, the need for long-term commitment to **highly migratory species**; enhancing stakeholder engagement and continuously supporting the development of expertise at various scales.

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# **BILLFISH INTERACTIONS, LIVELIHOODS, AND LINKAGES FOR FISHERIES SUSTAINABILITY IN THE WESTERN INDIAN OCEAN (BILLFISH-WIO)**

## **1.0 Introduction**

### **1.1 Background and Scientific Rationale**

Highly mobile pelagic fish species like billfishes continue to decrease in their abundance, range, and productivity due to fisheries-induced threats (Pons *et al.*, 2017; Worm & Tittensor, 2011; Jensen *et al.*, 2010). These noted effects on billfish populations have resulted in significant implications in their habitat use, ecosystem functioning, conservation, and management across the subtropical and tropical oceans that they occur (IOTC, 2017; Lynch *et al.*, 2011; Collette *et al.*, 2011, ICCAT, 2006; Worm & Myers, 2003). Furthermore, challenges of multiple user groups, climatic change and a general lack of research on billfish requires attention due to systemic implications on sustainability of billfish resources, food and economic security, and sound governance (Kerstetter & Schratwieser, 2018; McIlgorm, 2010; Srinivasan *et al.*, 2010). The Western Indian Ocean (WIO) billfish populations are not an exception. Given the projection of a nearly 50% increase in the WIO region's population from 220 million in 2015 to 306 million by 2030 (Gerland *et al.* 2014; Obura *et al.*, 2017), there is urgent need to evaluate impacts on marine fisheries to ensure sustainability, socio-cultural and economic security, and good governance.

Billfishes comprise two families, Istiophoridae and Xiphiidae, and six species found in the WIO, sailfish (*Istiophorus platypterus*), blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), striped marlin (*Tetrapturus audax*), broadbill swordfish (*Xiphius gladius*), and the short-billed spearfish (*Tetrapturus angustirostris*) (Howard & Stark II 1975; Kadagi *et al.*, 2011, 2017; Harris *et al.*, 2013). Broadly, management of billfish in the WIO countries is complicated, primarily due to lack of information on indirect and direct capture and on lack of consensus on their composition (Kadagi *et al.*, 2011). Hence, the proposed work applied an interdisciplinary approach to bridge knowledge gaps through understanding billfish interactions (socio-ecological), associated livelihoods (socio-economic characteristics) and linkages (governance) to support sustainable fisheries in the WIO. The relevance of this first-time regional project was evidenced by the limited number of studies on billfish in the WIO. A search through the Western Indian Ocean Marine Science Association (WIOMSA) symposium reports indicated that only two presentations on billfishes had been done in the last four consecutive WIOMSA symposiums 2010 – 2018.

Although the presence of billfish placed the coast of East Africa and the WIO region on the world map of recreational billfish fishing, there was limited scientific knowledge and data. Data collection has often been hampered by a lack of systems in place to ensure continuity of data collection process, remoteness of the landing sites, the extensiveness of the coastlines, and inadequate training on species identification resulting in species being lumped together or misidentification. Involving fishers and associated stakeholders in data collection through capacity development and introduction of new technology such as data collection phone

applications (phone App) would promote citizen science and provide real time transfer of catch landings and additional data. In 2016-2017, the Indian Ocean Tuna Commission (IOTC) through the Working Party on Billfish initiated a standardized database for reporting of data on tuna and billfish from recreational fisheries (Pepperrell *et al.*, 2017). Building on this progress, BILLFISH-WIO aimed to engage the different fishers (bottom-up approach) and stakeholders to collect and report historical and current data on billfish to complement National Fisheries Institutions and their compliance with IOTC data submission requirements for billfish.

Studies on spatial and temporal distribution of billfishes were lacking in the WIO. Several findings had shown that significant limitations and gaps in data for the Indian Ocean tuna and tuna-like fisheries were a major challenge in the potential and efficacy of existing pelagic spatial management efforts (Herrera & Pierre, 2010; Koldewey *et al.*, 2010, Lynch *et al.*, 2011, Romanov, 2002). In 2014 - 2015, the African Billfish Foundation (ABF) in partnership with the Kenya sport fishing fraternity and the International Game Fish Association (IGFA) deployed the first-time Pop-up Satellite Tags (PSAT) on marlin. The PSATs showed that billfish had varied spatial and temporal distribution. For example, a black marlin swam for a total estimated distance of 3,026 nm from Kenya to the Gulf Eden. Following these advancements, BILLFISH-WIO focused on the need to increase the scope of study on mapping and understanding billfish fisheries using traditional and advanced techniques whilst engaging citizen science to provide better inferences on the distributions of billfish species and associated fisheries.

In recent years, genetic studies on Istiophoridae billfish populations have been one of the priority research areas for the IOTC. Yet, little was known about the genetic composition and population structure of these species in the WIO. Investigations on the striped marlin (*Kajikia audax*) had indicated distinct breeding populations in the Pacific Ocean (Purcell, 2009; Purcell & Edmands 2011) whereas little to no information existed for the WIO billfish stocks especially striped, black marlin, blue marlin and sailfish which were all currently considered to be either subject to overfishing and/or overfished; and subsequently listed as high priority for the data collection (IOTC 2016; 2017). Molecular distinction of billfishes was still poor in the IO region (Hanner *et al.*, 2011). Notably, IOTC had assumed a single stock hypothesis for billfish stocks in the Indian Ocean. While earlier work had been undertaken to suggest the black marlin may comprise single stocks (Williams *et al.*, in review) there had been little to no studies conducted to evaluate the stock structure of other species in the Indian Ocean (Graves & McDowell 2015). BILLFISH-WIO aimed to advance our understanding of the genetic structure of key species such as sailfish and marlin in the Western Indian Ocean.

While fishing and the development of Ecosystem Approaches to Fisheries (EAF) to address issues such as food security and alternative income have been more pronounced in freshwater systems, limited efforts had been directed in marine ecosystems, particularly for artisanal and recreational fisheries that target billfish. As such, there is still inadequate information on the socio-economic contribution of billfish species regionally. One of the few known studies on the socio-economic contributions of billfish was conducted by Williams (1970), who estimated that the capital investment in the Kenyan sport fishery was about \$560,000 in 1960 and \$840,000 in 1964. By exploring the socio-economic contribution and governance of billfish, BILLFISH-WIO aimed to

increase availability of evidence on the impact of billfish and associated fisheries on livelihoods and the need for governance at national and regional scale.

## 2.0 Goals and Objectives

BILLFISH-WIO aimed to enhance information on billfish interactions (socio-ecological), associated livelihoods (socio-economic characteristics) and linkages (governance) which have manifold implications on overall species health, ecosystem functioning, food and economic security, and multiscale management given the transboundary nature of these species.

The specific objectives included:

1. Evaluation of the historical and present status of billfish species
2. Determining the spatial and temporal distribution of billfish species
3. Assessing the genetic structure of critical species
4. Exploring the socio-economic contribution and governance of billfish

## 3.0 Detailed progress on project goal and objectives

The BILLFISH-WIO Project (<https://billfishwio.com>) brought together an interdisciplinary team of over 20 collaborators, experts, researchers, and stakeholders, including 4 Ph.D. and 6 MSc. and 2 BSc researchers. The presence of diverse collaborators ensured the delivery of expected outputs within the country and at the regional level. Working with students was an opportunity to train early career scientists, enabling documentation of in-country knowledge through reports and publications, and creation of awareness. In this final report, we outline and detail our accomplishments, highlight some of the challenges and opportunities, share lessons learnt and provide a way forward and plan of action beyond the project.

To date, the project has exceeded the expected deliverables on the set objectives which range from publications, awards and grants, collaborations, media outputs and developing capacity through working students (*See table 1*).

Each objective was led by a component team leader and comprised of several activities and collaborations as follows:

### 3.1 Fieldwork, Data Collection, and Analysis

Between September 2019 and December 2022, the project worked in the following areas:

- **Kenya** - Quantitative and qualitative catch and socioeconomic data was collected between September 2020 until May 2021 at various landing sites in the north and south coast. Catch data collection included sampling for project objectives and student work. Further, data collection encompassed genetic tissue collection for DNA extraction at Pwani University. Student researchers and community representatives also collected

information from Focus Group Discussions (FGDs) and semi structured interviews. Beyond fieldwork, historical data from sport fisheries was obtained from the Kenya Association of Sea Anglers (KASA) and analyzed as part of an undergraduate final report (by Joey Ngunu). These sport fishers' landings data along with billfish tag and release data was incorporated into a regional billfish manuscript. The project obtained additional data from Global Fish Watch and the Ocean Biodiversity Information System (OBIS) for longline fisheries catching billfish as bycatch - these datasets have been analyzed and included in a publication (submission led by Pascal Thoya – Ph.D student (now Dr Thoya).

- **Mozambique** – We collaborated with Key Traceability, a large-scale fishing company operating out of Mozambique to enhance data collection. Data collected on the ground included capture data from commercial vessels operating in central Mozambique. Plans are still underway to share this data for future scientific communication on billfish in Mozambique. The project also obtained sport fisheries historical dataset from 1958 which detailed billfish data from Pemba Bay, Beira, Ponta d'Ouro and Bazaruto. Genetic samples were collected from Pemba Bay and Beira while artisanal open-ended questionnaires were administered in Pemba Bay.
- **Somalia** - Our team completed the collection of socio-economic data in Kismayo, Berbera and Mogadishu while genetic tissue sampling was conducted in Mogadishu, Kismayo, Berbera and Bosaso. Collaboration with Somalia has continued through partnership with Secure Fisheries and Project Kalluun (<https://securefisheries.org/project-kalluun-collecting-somali-catch-data>). Through support from the Pew Marine Fellowship, the Somali students have been involved in regular data collection at three sites in the country collecting both catch data, tissue and eDNA samples. Relatedly, the support from WIOMSA MASMA and WIOMSA MARG I grant has been instrumental in supporting Salma Ahmed, our MSc student from Somalia to proceed to her second year of studies at Pwani University.
- **Tanzania** - Data collection was finalized at Dar es Salaam (Kunduchi, Ununio, Minazi mikinda, Ferry integrated fish market), Mafia Island (Kilindoni, Kiegeani, Jibondo, Mfuruni, Bweni, Bwejuu Island), Mtwara (Ferry market and landing site) as well as Zanzibar (Stone town and Nungwi). It was however not possible to visit Nyororo Island which is popular with billfish fishermen as women are forbidden from going to that island. Findings from two study sites: Mafia Island and Dar es Salaam revealed that the key actors involved in the billfish value chain were fishers, vessel and gear owners, input suppliers, auctioneers, middlemen, processors, and final consumers; there was no value addition process performed at the production stage of the chain (fishers). The value addition was observed, and the value addition processes involved salting and sun-drying, freezing in ice, cleaning, degutting and filleting. Salting and sun-drying was practiced only in Mafia by few traders who transport billfish to coastal markets in Southern regions (i.e, Mtwara and Lindi). Traders who transport billfish from Mafia to Dar es Salaam or supply in hotels normally preserve the fish in box ice to avoid spoilage and the average price at production level was 6,000 TSh/kg and 3,500 TSh/kg in Dar es Salaam and Mafia respectively while the average price at consumer level was 7,000-10,000 TSh and 6,000 TSh in Dar es Salaam and Mafia respectively. Findings suggested

the need to generate billfish resource use for sustainable management (work done by MSc student Emmy Mwanjali).

- **Comoros** - Through funding from the Pew Project and partnership with the National Research Institute for Agriculture, Fisheries and Environment (INRAPE) in Comoros; the project supported awareness creation preceding billfish data collection in Ngazidja Island in Comoros. The Pew fellowship enabled facilitation of both awareness and data collection activities in Comoros. This was crucial in gathering information for regional management action. Socio-economic surveys were also conducted. Finally, an MOU between KMFRI and INRAPE is currently under review at the State Department for Fisheries, Aquaculture and The Blue Economy in Kenya to facilitate collaboration between the two countries.
- **South Africa** - The project worked with three collaborators making it possible to analyze historical, recreational, and commercial billfish data. Findings were incorporated into the regional review paper published in the Reviews in Fish Biology and Fisheries journal.

### 3.2 Project Partnerships

BILLFISH-WIO's focus at national, regional, and global scale has been central in developing partnerships which were critical to executing the objectives as follows:

#### **Mozambique**

- The project worked with Afritex and Key Traceability to facilitate sharing of catch and historical data for Mozambique and other areas.
- A long-term sportfishing captain - Duarte Morato shared his photo gallery allowing the project accessibility to past and current billfish photos and videos.

#### **South Africa**

- The team partnered with researchers from the Oceanographic Research Institute (ORI) on the analysis of available data on billfish which significantly contributed to the Review Paper.

#### **Kenya**

- Through partnership with the Pew Marine Fellowship, the team conducted an art survey to determine the existence of billfish in different art categories at the coast. A technical report was produced, one manuscript was submitted and is under review at the WIOMSA Marine Science Journal while another manuscript is under preparation.

#### **Somalia**

- In Somalia, there is partnership with Project Kalluun, an initiative of One Earth Future – Secure Fisheries which connects 4 universities (City University- Mogadishu, East Africa University- Bosaso, Berbera Maritime and Fisheries Academy, Kismayo University) and provides video lectures and training for students in data collection. Through BILLFISH-WIO there have been a series of lectures on billfishes and genetic tissue sampling while funding

from the Pew fellowship (*see notes on additional funding*) has supported public education and outreach. The students were competitively selected to participate in education and outreach. In return, the Project Kalluun students shared their monthly catch data with the BILLFISH-WIO project.

#### **Comoros**

- Through funding from Pew Charitable Trusts, BILLFISH-WIO worked with the National Fisheries Research Institution, Institut National De Recherche Pour L'agriculture, La Pêche Et L'environnement-Comoros to promote collaboration on billfish data collection and reporting.

#### **Regional and global scale**

- Through Dr. Isigi Kadagi as one of the Marine Conservation Action Fund (MCAF) Fellows, the project was assigned two sets of interns from the Harvard College Conservation Society (HCCS) led by their President Marissa Garcia and team leaders to continue the work on the project's communications and outreach strategy. The goal was to increase the visibility of BILLFISH-WIO work and conduct interviews among project team members. The teams also successfully ran a twitter campaign showcasing women in the BILLFISH-WIO project and interviewed more than 13 of our project collaborators.

#### **Regionally – WIO**

- Progress is underway on the extraction of DNA and analysis of genetic samples through our partnership with Dr. Sammy Wambua (Pwani University) and Laura Smith, a PhD student working with Dr. Sam Williams and Dr. Julian Pepperell (University of Queensland, Australia). The WIO sailfish samples were collated into a larger collection (564 samples) from 16 different countries. They will also be compared with sailfish caught off Western Australia. Ms. Smith is currently working on the SNP data. She has also developed and launched a survey of game fishers about involvement in billfish research as citizen scientists in Australia (<https://sites.google.com/view/billfish-survey/home>).

### **3.3 Dissemination of Finding and Outcomes**

- The project was featured on the Smithsonian Institute Optimism Series.
- The writing of the billfish book, entitled "Billfish in Africa: Perspectives from the Western Indian Ocean" is underway and illustrations are almost finalized.
- The writing of the 5-series Billfish Children's book is underway.
- Reelmedia (Tim Webster and Aiyana Gane) undertaking a public-facing campaign of the Ocean Decade commissioned by IOC-UNESCOs requested our project to feature in the Ocean Science stories.
- The project team put in a lot of effort to increase the visibility of the project in-country, regional and internationally. This was evidenced by regular presence in each of the WIOMSA News briefs including pioneering "the Opinion" column.
- The project was featured in the UN Decade Early Career Ocean Professional webinar hosted by WIOMSA.
- The project Twitter handle - @billfishwio and the Researchgate page (<https://www.researchgate.net/project/Billfish-Interactions-Livelihoods-and-Linkages->

for-Fisheries-Sustainability-in-the-Western-Indian-Ocean-BILLFISH-WIO) regularly posts information and retweets about billfish and associated resources and activities.

- The project has a website: <https://billfishwio.com/>

## 4.0 A summary of Scientific Outputs and Outcomes (Publications and Studentships)

Objective 1: Evaluate the historical and present status of billfish species

**Activity 1.1:** Review of historical and current billfish landings and catch rates in WIO fisheries

Output 1: [Status and Challenges for Sustainable billfish fisheries in the Western Indian Ocean](#)

Status, Challenges and Recommendations for Sustainable Billfish Fisheries in the Western Indian Ocean By: Kadagi, N.I., Wambiji, N., Mann, B., Parker, D., Daly, R., Rato, D.A.M., Halafo, J., Gaspare, L., Sweke, E.A., Ahmed, S., Saverio, R., Maina, J., Glaser, S., Sumaila, R (Published)

### Background

Data on billfish species in the Western Indian Ocean remains poorly documented. Billfish in the WIO have also attracted less research attention even though the Indian Ocean Tuna Commission (IOTC) – Working Party on Billfish has made efforts to promote data collection and reporting by Member States and Contracting Parties (CPCs).

Our work provided a comprehensive overview of billfish fisheries in the Western Indian Ocean countries with the objectives of documenting available historical data and local ecological information, identifying knowledge gaps and contributing to ongoing discourses on sustainable fisheries at local and regional scale, particularly for transboundary species.

### Methods:

We gathered information and data from a wide range of sources such as reports, databases, grey literature, and peer reviewed publications. We also relied on National Reports to IOTC to obtain fisheries data. Information on reported and unreported billfish catches was obtained from IOTC and Sea Around US databases.

### Results and discussion

Our work highlighted that billfish fisheries in the WIO are highly diverse and consist of two segments – the coastal and oceanic, and that billfish have social, economic, and cultural value across the different countries. Swordfish are targeted by large-scale and semi-industrial fisheries while other billfish species are sought after by sport and artisanal fishers.

Output 2: Estimated catch per unit effort (CPUE) for sport and recreational fisheries of sailfish using catch records from Kenya Association of Sea Anglers (KASA) from 1991 to 2021 (manuscript)

- Mr Joey Ngunu graduated with a Bachelor's degree from Pwani University after submitting a thesis - Estimating catch per effort for sport and recreational fisheries targeting billfish along the Kenyan coast while supervised by Dr. Kadagi and Ms. Kinyua.

## **Background**

No doubt about it; the Western Indian Ocean (WIO) region is a prominent destination for marine recreational and sport fishers as evidenced by the historical pursuit of fish species renowned for their fighting skills such as billfish. Countries such as Kenya, Mauritius, Mozambique and South Africa have a long history of sport and recreational fisheries, with organized charter and guided fishing operations mostly carried out using rod and line with hook and line to catch fish. Participants in the WIO marine recreational fishing often target multi-species which inhabit either inshore or offshore areas. However, marine recreational and sport fishing in many WIO countries remain understudied and under-represented in conventional discussions on the role of fisheries in development agendas and sustainable fisheries management.

We sought to review the challenges and opportunities for the sustainable development of recreational and sport fishing in the WIO. First, we noted that various names are used interchangeably to refer to marine recreational fishing in the region. Thus, there is no regionally accepted single definition of what constitutes sport and recreational fisheries. Even with these differences in definitions, our review recognized that WIO marine recreational fisheries refer to non-commercial harvesting, motivated by catching for leisure, food, fun, competition, sport or camaraderie, and the catch is not meant for sale. La Reunion is an exception where sport fishing charter operators are referred to as professional operators and may sell their catch.

## **Key findings**

We identified the challenges facing the development of recreational and sport fishing in two broad categories, namely (i) governance and (ii) economic and socio-cultural. By examining these categories, we provided a multi-scale and socio-ecological context of how a failure to understand the human dimensions, the target species and their habitats, and governance structures can inhibit the successful development of sustainable sport fishing in the WIO. We also highlight that the discourse on the potential of sport fishing and the need for their development at regional scale is often a 'one-size fit all' perspective and fail to account for the nuances that can impede the growth of this fishery at country level. Relatedly, we acknowledge that the challenges for developing sustainable recreational and sport fisheries in the WIO are diverse, and complex, and thus there are no simple fixes to massive systemic challenges, especially in data poor regions.

Then how can sport and recreational fisheries contribute to sustainable development in the context of the WIO region? We assert that there is an opportunity to develop sustainable sport and recreational fishing in the region. Entities engaged in the recreational sectors must consider the involvement of local communities in decision making and benefit sharing. Likewise, coordination in the multi-government agencies and multi-government and non-government

efforts would be critical in integrating the recreational fisheries in the local and national agenda. More importantly, sustainably developing and managing recreational and sport fishing in the WIO will require a systematic paradigm shift that considers the dynamics of this fishery, the anticipated changes in societal values, cooperation of multiple stakeholders and the long-term sustainability of the shared fisheries resources.

Our review represents a first step in prioritizing and designing strategies that can contribute to the sustainable development and management of recreational and sport fishing in the WIO. The insights offered in this paper can inform practice for this sector in other parts of the world, which may be facing similar challenges.

#### Output 4: Additional outputs and outcomes for Objective 1:

- Student presentations regarding their research work at the Project Kalluun seminar series
  - (Bi –weekly Project Kalluun Seminar Series 2 2022. Seminar involved BILLFISH-WIO students collaborating with counterparts from 4 Somalia based universities and guest speakers).
  - University teams’ mock competition to gauge understanding of billfish issues following presentations by BILLFISH\_WIO PIs at the Project Kalluun seminar series
- Assorted billfish awareness dissemination through BILLFISH-WIO website update
  - BILLFISH –WIO website updates (<https://billfishwio.com>)
- Assorted billfish awareness dissemination through BILLFISH-WIO twitter handle that also led to an increase in the number of followers
  - Twitter progress report of whole project  
<https://twitter.com/billfishwio/status/1326967232262328321?s=24>
- Peer reviewed publications and newsbrief articles by project team members
- Translation of introductory billfish presentations into French, Kiswahili and Somali
- Presentation about Billfish of WIO during the Floating University Research cruise on 4<sup>th</sup> July 2022 on board RV Marion Dufresne

#### Objective 2: Determining the spatial and temporal distribution of billfish species

- Pascal Thoya graduated with a PhD from The University of Hamburg in Germany and Macquarie University in Australia.
- He modelled data from the larger Indian Ocean region having collated data from Ocean Biogeographic Information System (OBIS) database and published a paper.
- A second manuscript is underway exploring the intersection between governance of highly migratory species and Post-2020 Conservation Biodiversity Targets.

#### Output 1: [Environmental controls of billfish species in the Indian Ocean and implications for their management and conservation](#)

Thoya, P., Kadagi, N.I., Wambiji, N., Williams, S.M., Pepperell, J., Möllmann, C., Schiele, K.S. and Maina, J., 2022.

#### **Background:**

The paper examined the spatial and temporal distribution of billfish species regarding fishing pressure, management status and climate-change driven environmental factors.

#### **Key findings**

- Swordfish are the most widely distributed of all billfish species living in the Indian Ocean (IO), with a projected fundamental niche occurring throughout the region
- Spatial overlap between longline fishing effort, and billfish. Distribution ranges suggests inadvertent fishing pressure on billfish populations as they are caught together with targeted Tuna. Distribution ranges were found to transcend maritime zones reinforcing a need to formulate effective management policies for marine areas beyond national jurisdiction.
- Temperature, MLD, oxygen and salinity were the most important variables in predicting niche preferences across all the model types but with species-specific difference in relative importance.

#### **Objective 3: Assess the genetic structure of critical species**

##### **Output 1: Billfish genetic sampling**

- A materials transfer agreement between KMFRI and UDSM was signed, and 286 tissue samples collected in Tanzania were transported to Kenya for DNA extraction.
- In Mozambique, 139 tissue samples were collected.
- In Kenya, over 400 billfish genetic samples were collected from a longliner cruise and from landing sites.
- In Somalia, approximately 250 samples were collected.
- Samples were sent to Australia where sequencing is being undertaken

##### **Output 2: Other outputs and outcomes for objective 3:**

- Ms. Pascah Beti graduated from Pwani University after developing a standard protocol for DNA isolation from billfishes for her final year thesis.
- Training in DNA isolation was conducted by Dr. Sammy Wambua.
- High quality DNA extracts were isolated from all samples from Somalia, Kenya and Tanzania at Pwani University at the PuBReC laboratory by 2 students – Rodney Omukuti and Mohamed Yusuf supervised by Dr. Sammy Wambua. Rodney won the prestigious Bioinformatics Internship with ICIPE while Mohammed got employed at Kiunga Community conservancy (KICOCO)
- Students in Somalia had first-hand experience in collection of DNA samples which yielded very good DNA samples.

Objective 4: Exploring the socio-economic contribution and governance of billfish

Output 1: [Ocean safaris or food: characterization competitive interactions between recreational and artisanal billfish fisheries on the coast of Kenya](#)

## **Background**

Scientific literature has raised broad and multiple issues regarding characterizing competitive interactions among fishers and in fisheries resources. These interactions have primarily been described using factors such as the distributions of fishing vessels, fishing effort, catch rates, and target species. However, there is a general lack of criteria to verify that these interactions among fisheries user groups are indeed competitive. A failure to identify competition among resource users groups can impact socio-cultural, economic, cultural and food security of coastal communities. Therefore, characterizing fisheries interactions across space and time is pivotal in developing ecosystem-based management strategies that account for multi-level interactions, especially for shared fishery resources.

Our research examined competitive interactions in recreational and artisanal fisheries with specific reference to billfish species in Kenyan waters. Our aim was to develop a set of criteria for inferring and classifying competitive interactions in recreational and artisanal billfish fisheries in the WIO region to address challenges that may arise from multiple resource use needs.

## **Key findings**

We found that sources of competitive interactions in the Kenyan artisanal and recreational billfish fisheries were heterogeneous based on the dimension of resource use and partitioning (i.e., type of resource, habitat, and period of fishing activity). Specifically, the interactions occurred because the two fisheries harvested the same billfish species, except striped marlin and spearfish, primarily present in recreational fisheries. Additionally, competition was attributed to periods of fishing activity which were influenced by seasonal changes- the northeast and southeast monsoons. Co-occurrence of target species in fishing grounds depicted the dependence of user groups on the same resource, resulting in competition. In the case of Kenya, recent years have seen an increase in “dinghies” which have the capability of reaching some of the fishing grounds, which were initially accessible by mostly sport and recreational fishing boats. The overlap in fishing grounds combined with direct capture of the same resources presents a unique challenge in understanding the implications of these interactions in the management of shared transboundary fisheries such as billfish.

Given the growing aspirations of many countries across the Western Indian Ocean (WIO) to explore the Blue Economy and implement marine spatial planning, our findings emphasize the importance of sustainable integrated systems which consider the needs of resource users at local and regional level.

## [Output 2: Potential for conflicts in recreational and artisanal billfish fisheries on the coast of Kenya.](#)

### **Background**

Intrasectoral fisheries conflicts between artisanal and industrial fisheries, and between recreational and artisanal sectors have been documented in various African countries. In some cases, fisheries conflicts occur due overlap in fishing grounds and ineffective formal governance and management systems. Fewer studies have focused on the factors that suggest potential for conflicts between recreational and artisanal sectors of billfish and other transnational fisheries resources in the WIO.

### **Key findings**

We explored the potential for conflicts in recreational and artisanal billfish fisheries by examining the characteristics of recreational and artisanal fishers and identifying key indicators of conflicts between recreational and artisanal billfish fisheries. We use a combined inductive and deductive approach to analyze data from semi-structured interviews completed with recreational and artisanal fishers at two sites (Malindi and Watamu) situated in Kilifi County on the Kenya coast. Our findings indicate the existence of different subgroups of artisanal and recreational billfish fishers which reflect the multi-level complexities and challenges the traditional dichotomous understanding of billfish fishing populations in Kenya and the WIO.

[Output 2: Kinyua DN, Kadagi NI, Ater S, Osore M and Wamukota A \(2022\) Perceptions towards governance of billfish resource use: The lens of artisanal fishers in Kenya. Front. Mar. Sci. 9:1032594. doi: 10.3389/fmars.2022.1032594 \(Published\)](#)

### **Key findings**

- Multiple fisher groups target billfish species, each with different motivations and experiences, which can influence the effectiveness and sustainability of governance approaches.
- Artisanal fishers have adequate knowledge of fishing laws and regulations, as well as governing institutions, their performance and effectiveness of governance intervention.
- Involvement of resource users promotes a bottom-up approach to the co-management of billfish which compliments the current regional and national efforts that have largely focused on commercial fisheries.

## 5.0 Tabulated summary of BILLFISH-WIO OUTPUTS AND OUTCOMES

Below we provide details of completed and ongoing project outputs and outcomes for the period between September 2019 and December 2022.

**Table 1: BILLFISH-WIO OUTPUTS AND OUTCOMES 2019 -2022**

| Authors                                                                                                        | Title                                                                                                                                  | Type of Output | Year | Submitted to                | Outcome                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|----------------|------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Published Papers</b>                                                                                        |                                                                                                                                        |                |      |                             |                                                                                                                                                                                                                                                                    |
| Kinyua, D.N., Kadagi, N.I., Ater, S., Osore, M. Wamukota, A.                                                   | <a href="#">Perceptions towards governance of billfish resource use: the lens of artisanal fishers in Kenya.</a>                       | Paper          | 2023 | Frontiers Marine Science    | First-time research on perceptions of billfish fishers on billfish governance. Multiple fisher groups target billfish species, each with different motivations and experiences, which can influence the effectiveness and sustainability of governance approaches. |
| Thoya, P., Kadagi, N. I., Wambiji, N., Williams, S. M., Pepperell, J., Möllmann, C., Schiele, K. S., Maina, J. | <a href="#">Environmental controls of billfish species in the Indian Ocean and implications for their management and conservation.</a> | Paper          | 2022 | Diversity and distributions | Niches for all billfish were identified across the Indian ocean realm with associated environmental                                                                                                                                                                |

|                                                                                                                                                                            |                                                                                                                                                                                 |       |      |                                                                           |                                                                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                            |                                                                                                                                                                                 |       |      |                                                                           | variables that supported the niche preferences                                                                                                          |
| Wambiji, N., Kadagi, N. I., Everett, B. I., Temple, A. J., Kiszka, J. J., Kimani, E., & Berggren, P.                                                                       | <a href="#">Integrating long-term citizen science data and contemporary artisanal fishery survey data to investigate recreational and small-scale shark fisheries in Kenya.</a> | Paper | 2022 | Aquatic Conservation: Marine and Freshwater Ecosystems, 32(8), 1306-1322. | Study highlights the importance of citizen science by recreational fishers in increasing awareness around the risks and threats to shark populations.   |
| Kadagi, N.I., Wambiji, N., Mann, B., Parker, D., Daly, R, Rato, D.A.M., Halafo, J., Gaspere, L., Sweke, E.A., Ahmed, S., Saverio, R., Maina, J., Glaser, S., Sumaila, U.R. | <a href="#">Status and challenges for sustainable billfish fisheries in the Western Indian Ocean.</a>                                                                           | Paper | 2022 | Fish biology and fisheries                                                | Clarity on billfish research in the WIO and potential interventions to be undertaken to fill the gaps or and maintain sustainable stocks of the species |
| Kadagi, N. I., Wambiji, N., & Swisher, M. E. (2020).                                                                                                                       | <a href="#">Potential for conflicts in recreational and artisanal billfish fisheries on the coast of Kenya.</a>                                                                 | Paper | 2020 | <i>Marine Policy</i> , 117, 103960.                                       | Existence of different subgroups of artisanal and recreational billfish fishers which reflect the multi-level complexities                              |

|                                                                   |                                                                                                                                                             |       |      |                                                     |                                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                   |                                                                                                                                                             |       |      |                                                     | in Kenya and the WIO; a starting point towards understanding features of recreational and artisanal billfish fisheries and identifying potential sources of intrasectoral conflicts.                                                                                                 |
| Kadagi, N. I., Wambiji, N., Belhabib, D., & Ahrens, R. N. (2021). | <a href="#">Ocean safaris or food: characterizing competitive interactions between recreational and artisanal billfish fisheries on the coast of Kenya.</a> | Paper | 2021 | <i>Ocean &amp; Coastal Management, 201, 105432.</i> | Competition was attributed to periods of fishing activity which were influenced by seasonal changes- the northeast and southeast monsoons. Co-occurrence of target species in fishing grounds depicted the dependence of user groups on the same resource, resulting in competition. |

|                                                                                                                     |                                                                                                                                                                                                            |                   |      |                                      |                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Okafor-Yarwood, I., Kadagi, N. I., Miranda, N. A., Uku, J., Elegbede, I. O., & Adewumi, I. J.                       | <a href="#">The blue economy–cultural livelihood–ecosystem conservation triangle: the African experience.</a>                                                                                              | Paper             | 2020 | Frontiers in Marine Science, 7, 586. | Recommend the adoption of collaborative framework which combines top and bottom-up approaches to the Blue Economy management. |
| <b>Conference oral and poster presentations</b>                                                                     |                                                                                                                                                                                                            |                   |      |                                      |                                                                                                                               |
| Kadagi, N. I. Ater, S., Stephenson, E. , Cedras, R., Wambua, S., Kinyua, D. N., Glaser, S., Wambiji, N., Osore, M., | <a href="#">Tackling today's Science, Research and Leadership for the Ocean Decade in the Western Indian Ocean</a>                                                                                         | Mini Symposium    | 2022 | WIOMSA Symposium                     | Making progress on creating a Working Group                                                                                   |
| Winkler, A., Wambij, N., Farthing, M., Kadagi, N. I.                                                                | <a href="#">Marine Recreational Fisheries in the Western Indian Ocean: Current and Future Research, Learning from the Covid-19 Pandemic And Its Effects On Marine Recreational Fisheries In The Region</a> | Special session   | 2022 | WIOMSA Symposium                     | Making progress on creating a Working Group<br>Possible first-time African recreational conference                            |
| Wambiji Nina                                                                                                        | Combining long-term and contemporary fishery data to protect Kenya's sharks                                                                                                                                | Oral presentation | 2022 | WIOMSA Symposium                     | Delivered                                                                                                                     |
| Farthing Matthew                                                                                                    | Fishing guides as role models to promote unenforceable, pro-environmental catch-and-release behaviours to recreational anglers                                                                             | Oral presentation | 2022 | WIOMSA Symposium                     | Delivered                                                                                                                     |

|                               |                                                                                                                                         |                   |      |                  |           |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------|------|------------------|-----------|
| Kinyua Damaris                | Characteristics and socio-economic contributions of artisanal billfish fishing in Kenya                                                 | Oral presentation | 2022 | WIOMSA Symposium | Delivered |
| Leong Eunice                  | Marine sport and recreational fisheries in Mozambique: A focus on Maputo National Park                                                  | Oral presentation | 2022 | WIOMSA Symposium | Delivered |
| Winkler Alexander             | Working with not against recreational anglers, using scientific interventions as a tool to endorse pro-environmental behaviour          | Oral presentation | 2022 | WIOMSA Symposium | Delivered |
| <b>Newsbrief and blogs</b>    |                                                                                                                                         |                   |      |                  |           |
| Kadagi Nelly                  | <a href="#">New Director for WWF's Education for Nature Program and Conservation Leadership</a>                                         | Appointments      | 2020 |                  |           |
| Wambiji Nina                  | <a href="#">Dr. Nina Wambiji discusses her Pew Fellowship award</a>                                                                     | Awards            | 2022 |                  |           |
| Kadagi Nelly                  | <a href="#">How can we detect potential for conflicts in recreational and artisanal billfish fisheries in the Western Indian Ocean?</a> | Newsbrief         | 2020 | WIOMSA Newsbrief | Published |
| Wambiji Nina and Kadagi Nelly | <a href="#">Understanding the highly Migratory billfish species in the Western Indian Ocean.</a>                                        | Newsbrief         | 2019 | WIOMSA Newsbrief | Published |
| Kadagi Nelly and Sarah        | <a href="#">Researching Together: The BILLFISH-WIO at One Year</a>                                                                      | Newsbrief         | 2020 | WIOMSA Newsbrief | Published |
| Nelly and Sarah               | <a href="#">Reimagining a future WIOMSA</a>                                                                                             | Newsbrief         | 2020 | WIOMSA Newsbrief | Published |
| Wambiji Nina and Kadagi Nelly | <a href="#">Defining competitive interactions among multiple fisheries resource user groups</a>                                         | Newsbrief         | 2020 | WIOMSA Newsbrief | Published |

|                               |                                                                                                                                              |                   |      |                  |           |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------|------------------|-----------|
|                               |                                                                                                                                              |                   |      |                  |           |
| Kadagi Nelly and Nina         | <a href="#">A first step in designing strategies for sustainable development and management of recreational and sport fishing in the WIO</a> |                   |      |                  |           |
| Wambiji Nina and Kadagi Nelly | An opportunity for sustainable marine recreational and sport fisheries in the Western Indian Ocean (WIO) region                              | Newsbrief         | 2022 |                  |           |
| Shakila Muendo                | <a href="#">Effects of subsidies on billfish fisheries in Kenya</a>                                                                          |                   |      |                  |           |
| Kadagi Nelly and Sarah        | The Future of Ocean Research in the UN Decade of Ocean Science - A Western Indian Ocean perspective                                          | Newsbrief         | 2021 |                  |           |
| Kadagi Nelly                  | Survival of the richest, not the fittest: Attempts to government African fisheries impact small-scale fisheries the most                     | Newbrief          |      |                  |           |
| Kadagi Nelly                  | <a href="#">What will it take to recover, reimagine and rebuild a successful blue economy in Africa?</a>                                     | Newsbrief         | 2022 |                  |           |
| Kadagi, N. I. and Ater, S.    | Celebrating our Ocean Champions: Julius Francis                                                                                              | Newsbrief article | 2022 | WIOMSA newsbrief | Published |
| Kadagi Nelly                  | <a href="#">Kenyan marine biologist grew up 17 hours by bus away from the ocean</a>                                                          | Communication     | 2020 | Forbes           | Published |
| Uku Jacqueline                | Integrating art into ocean literacy for policy and practice in Kenya                                                                         | Oral presentation | 2022 | WIOMSA Symposium | Delivered |
| Kihia Susana                  | The inclusion of artists in ocean science communication                                                                                      | Oral presentation | 2022 | WIOMSA Symposium | Delivered |

|                                                                                           |                                                                                                                                                                                |                         |             |                                                        |           |
|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------|--------------------------------------------------------|-----------|
| Aaron Emily                                                                               | Value chain analysis of small-scale billfish fisheries in mainland Tanzania: Implications for management and sustainable use                                                   | Oral presentation       | 2022        | WIOMSA Symposium                                       | Delivered |
| Hassan, J., Glaser, S., Kadagi, N.I., Wambiji, N.                                         | Project Kalluun student exchanges                                                                                                                                              | Oral presentations      | 2020 - 2022 | BILLFISH-WIO and Secure Fisheries                      | Delivered |
| Wambiji, N., Kadagi, N. I., Everett, B. I., Temple, A., Kiszka, J., Kimani, Berggren, P., | <a href="#">Integrating long-term citizen science data and contemporary artisanal fishery survey data to investigate recreational and small-scale shark fisheries in Kenya</a> | Paper                   | 2022        | Aquatic Conservation: Marine and Freshwater Ecosystems | Published |
| <b>Media coverage and publicity</b>                                                       |                                                                                                                                                                                |                         |             |                                                        |           |
| Kadagi, N. I., Ater, S.                                                                   | BILLFISH-WIO team member spotlights                                                                                                                                            | Social media posts      | 2022        | Twitter                                                | Published |
| Kadagi, N. I.                                                                             | Shaping the Future of Ocean Science and Leadership Capacity in the WIO                                                                                                         | Keynote address         | 2022        | WIOMSA Symposium                                       | Delivered |
|                                                                                           | Blue Sessions                                                                                                                                                                  |                         |             |                                                        |           |
|                                                                                           | <a href="#">Studying the gladiators of the sea: Indian Ocean billfish</a>                                                                                                      |                         |             |                                                        |           |
| Wambiji Nina and Kadagi Nelly                                                             | Billfish research in the Western Indian Ocean region                                                                                                                           | Talk                    | 2022        | Science Café                                           | Delivered |
| Wambiji Nina                                                                              | World Fisheries Day celebration                                                                                                                                                | TV interview            | 2021        | NTV                                                    | Delivered |
| Yarwooda, I., Kadagi, N. I., Belhabib, D., Allison, H. E                                  | Survival of the Richest, not the Fittest: Impacts of Fisheries Governance Mechanisms on African small scale marine fisheries                                                   | Paper – GOVERNANCE SEC. | 2021        | Marine Policy                                          | Published |

|                                                                |                                                                                                                                                  |                     |      |                                   |           |
|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|-----------------------------------|-----------|
| Kinyua Damaris                                                 | Fishers' perceptions on billfish resources use along the Kenyan coast: Implication for management and governance                                 | Poster              | 2021 | WIOGEN conference                 | Delivered |
| Wambiji Nina                                                   | Understand highly migratory fish species amidst shifting dynamics: A focus on billfish species                                                   | Webinar             | 2020 | VirtualBlueDecade                 | Delivered |
| <b>Technical reports</b>                                       |                                                                                                                                                  |                     |      |                                   |           |
| Kadagi, N. I., and Wambiji, N.                                 | Contribution of Sustainable Fisheries to the Blue Economy of the Eastern Africa, Southern Africa and the Indian Ocean Region – ECOFISH Programme | Regional report     | 2021 | IOC                               | Delivered |
| Uku, J., Kihia, S., Ater, S.                                   | A Study into Kenyan Coastal Ocean Art with a focus on billfish                                                                                   | Technical Report    | 2021 | KMFRI                             | Delivered |
| Wambiji, Nina, Kinyua Damaris, Muendo Shakila and Kadagi Nelly | Evaluation of the current catch and socioeconomic aspects of billfish research in the Kenyan coast                                               | Technical Report    | 2021 | KMFRI                             | Delivered |
| Ngunu Joey                                                     |                                                                                                                                                  | Video clip          | 2021 | V.ECOP                            | Delivered |
| Gaspere Lydia                                                  | Billfish Interactions, Livelihoods and Linkages for Fisheries Sustainability in the Western Indian Ocean                                         | Poster presentation | 2021 | UDSM Research and Innovation Week | Delivered |
| Ater Sarah and Kadagi Nelly                                    | Opinion piece                                                                                                                                    | Newsbrief article   | 2021 | WIOMSA Newsbrief                  | Published |
| Muendo Shakila                                                 | Effects of subsidies on billfish fisheries in Kenya                                                                                              | Newsbrief article   | 2021 | WIOMSA Newsbrief                  | Published |
| Kinyua Damaris                                                 | Fishers' perceptions on billfish resources use along the Kenyan                                                                                  | Newsbrief article   | 2021 | WIOMSA Newsbrief                  | Published |

|                                                                    |                                                                                                                                                |                     |      |                                                 |           |
|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|-------------------------------------------------|-----------|
|                                                                    | coast: Implication for management and governance                                                                                               |                     |      |                                                 |           |
|                                                                    | Defining competitive interactions among multiple fisheries resource user groups                                                                | Newsbrief article   | 2021 | WIOMSA Newsbrief                                | Published |
|                                                                    | A first step in designing strategies for sustainable development and management of recreational and sport fishing in the WIO                   | Newsbrief article   | 2021 | WIOMSA Newsbrief                                | Published |
| Ngunu Joey                                                         | Encounters with the gladiators of the sea                                                                                                      | Newsbrief article   | 2021 | WIOMSA newsbrief                                | Published |
| Kadagi, N.I, Wambiji, N., Belhabib, D., Ahrens, R.                 | Ocean safaris or food: characterising competitive interactions between recreational and artisanal billfish fisheries on the coast of Kenya     | Paper = objective 1 | 2021 | Ocean and Coastal Management                    | Published |
| Kadagi, N.I, Wambiji, N., Fennessy, S, D., Allen, M.S., Ahrens, R. | Challenges and opportunities for sustainable development and management of marine recreational and sport fisheries in the Western Indian Ocean | Paper = objective 1 | 2021 | Marine Policy                                   | Published |
| Kadagi, N. I., Wambiji, N, Swisher, M. E                           | Potential for conflict in recreational and artisanal billfish fisheries on the coast of Kenya                                                  | Paper               | 2020 | Marine Policy                                   | Published |
| Kadagi, N.I.                                                       |                                                                                                                                                | Oral presentation   | 2020 | 18 <sup>th</sup> IOTC working party on billfish |           |
| Kinyua Damaris                                                     | Using citizen science to characterize socio-economic contributions of billfish fisheries in the Western Indian Ocean                           | Oral presentation   | 2020 | International Marine Conservation Congress 6    | Delivered |

|                                  |                                                                                                                                                      |                   |      |                                            |           |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------|--------------------------------------------|-----------|
| Ater Sarah                       | Ending Fisheries Conflict: An Elusive Catch                                                                                                          | Oral presentation | 2021 | Northwest Collaborative Futures Conference | Delivered |
| <b>BILLFISH-WIO Studentships</b> |                                                                                                                                                      |                   |      |                                            |           |
| Ngunu Joey                       | Evaluation of catch per unit effort of indo-pacific sailfish in marine sport and recreational fishing along the Kenyan coast                         | Bachelors         | 2021 | Pwani University                           | Graduated |
| Beti Pascah                      | Optimization of a standard protocol for DNA isolation from WIO billfishes                                                                            | Bachelors         | 2021 | Pwani University                           | Graduated |
| Muendo Shakila                   | Examining the effects of subsidies on billfish fisheries and the need for consensus on regional governance along the Kenyan Coast                    | Masters           |      | Pwani University                           | On-going  |
| Ali Salma                        | The socio-economic contribution of billfish to Somalia's fishing sector                                                                              | Masters           |      | Pwani University                           | On-going  |
| Leong Eunice                     | Assessing the characteristics, catch dynamics and socio-economic impacts of sport and recreational fisheries in Ponta do Ouro Marine Partial Reserve | Masters           |      | Eduardo Mondlane University                | Ongoing   |
| Aaron Emmy                       | Socio-economic drivers and value chain analysis of small scale of billfish fishery: Implications for management and sustainable use in Tanzania      | Masters           |      | University of Dar es Salaam                | On-going  |
| Thoya Pascal                     | Incorporating ecosystem-based                                                                                                                        | PhD               | 2022 | Macquarie University and                   | Graduated |

|                                                   |                                                                                                                                                                               |             |      |                             |                                                       |
|---------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|-----------------------------|-------------------------------------------------------|
|                                                   | management in marine spatial planning                                                                                                                                         |             |      | University of Hamburg       |                                                       |
| Kinyua Damaris                                    | Characterisation of billfish utilisation, socioeconomic pathways and governance along the Kenyan Coast                                                                        | PhD         |      | Pwani University            | On-going                                              |
| Halafo Jose                                       | Reproductive patterns, habitat selection and socio-economic interactions of billfish species with special attention to the black marlin in Bazaruto national park, Mozambique | PhD         |      | Eduardo Mondlane University | To start                                              |
| Ater Sarah                                        | An assessment of the socioeconomic impact of conflict between recreational and artisanal billfish fisheries in Kenya                                                          | PhD         |      | University of Nairobi       | On-going                                              |
| Adisa Sylvia                                      | Assessing the contribution of Women, the production of Blue Foods in the Western Indian Ocean (WIO): A case study of Billfish fisheries on the Kenyan coast                   | Masters     |      | University of Florida       | Ongoing                                               |
| <b>Team awards, recognition, and appointments</b> |                                                                                                                                                                               |             |      |                             |                                                       |
| Omukuti Rodney                                    | Winner of Bioinformatics Internship at ICIPE                                                                                                                                  | Award       | 2022 | ICIPE                       | On-going                                              |
| Mohamed Yusuf                                     | Manager, Kiwayuu Community Conservancy                                                                                                                                        | Appointment | 2022 | Kiwayuu Conservancy         | Currently student at VUB Belgium Master's scholarship |

|                                                |                                        |                                               |           |                                   |           |
|------------------------------------------------|----------------------------------------|-----------------------------------------------|-----------|-----------------------------------|-----------|
| Kinyua Damaris                                 | Winner poster presentation             | Award                                         | 2021      | WIOGEN Conference                 | Completed |
| Kinyua Damaris                                 | Winner poster presentation             | Award                                         | 2022      | WIOMSA Symposium                  | Completed |
| BILLFISH-WIO team                              | Mention of remarkable achievement      | Mention                                       | 2021      | WIOMSA annual report              | Completed |
| Kadagi Nelly                                   | Emerging Scientist Award               | Award                                         | 2021      | WIOMSA                            | Completed |
| Gaspere Lydia                                  | Research and Innovation week winner    | Award                                         | 2021      | UDSM Research and Innovation Week | Completed |
| Sammy Wambua                                   | Environmental and Social Impact Grant  | Grant                                         | 2022      |                                   | Ongoing   |
| Wambiji Nina                                   | Cassagnol Fellowship                   | Grant                                         | 2022      | WWF-EFN                           | On-going  |
| Wambiji Nina                                   | Pew Marine Fellowship                  | Award                                         | 2020      | Pew Charitable Trust              | On-going  |
| Kadagi Nelly                                   | Emergency response for data collection | Grant                                         | 2020      | MCAF                              | Completed |
| Aaron Emily                                    | Research support Mafia Island          | Grant                                         | 2020      | MARG I                            | On-going  |
| Ali Salma                                      | Research support Somalia               | Grant                                         | 2020      | MARG I                            | On-going  |
| Kinyua Damaris                                 | PhD study and research support         | Grant                                         | 2020      | WWF EFN                           | On-going  |
| Ater Sarah                                     | PhD study and research support         | Grant                                         | 2021      | MCAF                              | On-going  |
| <b>Extended collaborations and engagements</b> |                                        |                                               |           |                                   |           |
| BILLFISH-WIO team                              | Somalia students exchange              | Information exchange and Capacity development | 2020-2022 | Secure fisheries/ Project Kalluun | On-going  |
|                                                | Comoros data collection                | Information exchange; Data collection         | 2021      | INRAPE                            | Concluded |

|                                       |                                                                                                                                             |                         |           |                             |           |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------|-----------------------------|-----------|
|                                       | Mozambique data collaboration                                                                                                               | Data collection         | 2020      | Afritex/ Key Traceability   | Concluded |
|                                       | Mozambique data collection (Duarte)                                                                                                         | Data collection         |           |                             | Completed |
|                                       | Zanzibar data collection (Dr. Salum)                                                                                                        | Data collection         |           | University of Dodoma        | Concluded |
|                                       | South Africa data collaboration (Oceanographic Research Institute (ORI))                                                                    | Data collection/sharing |           |                             | Concluded |
| Kadagi, N. I., Wambiji, N., Osore, M. | Capacity development for project students in research questions, data analysis, scientific writing, communication                           | Training                | 2020-2022 | BILLFISH-WIO collaborators  | Concluded |
| Gaspere Lydia                         | Capacity development for project team in Tanzania, Nvivo, network analysis                                                                  | Training                | 2021      |                             | Concluded |
| Wambiji Nina                          | Ecole Blue - Presentation about Billfish of WIO during the Floating University Research cruise on 4th July 2022 on board RV Marion Dufresne | Research cruise         | 2022      | On board RV Marion Dufresne | Completed |
| Kadagi Nelly                          | Early Career Ocean Exchange: Finding your voice and using it                                                                                | Speaker                 | 2022      |                             | Concluded |

**Table 2: Summary table of all BILLFISH-WIO activities: Colour codes: Orange = Not achieved, Yellow = Partially achieved, Blue = Achieved, Green= Achieved and exceeded**

| Activities                                                                                                                               | Progress | Comments                                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Objective 1: Evaluate historical and present status of billfish species in the WIO</b>                                                |          |                                                                                                                                                                                                                                                                                                                   |
| 1. Review of historical and current billfish landings and catch rates in WIO fisheries                                                   |          | <ul style="list-style-type: none"> <li>• 3 papers published</li> <li>• One manuscript in preparation</li> <li>• One BSc graduated</li> <li>• Comprehensive database incorporating billfish data from Somalia, Kenya and Tanzania created</li> </ul>                                                               |
| <b>Objective 2: Examine the distribution and habitat association of billfish across transboundary levels in the Western Indian Ocean</b> |          |                                                                                                                                                                                                                                                                                                                   |
| 1. Determine the distribution and habitat preferences of billfish species across transboundary levels in the Western Indian Ocean        |          | <ul style="list-style-type: none"> <li>• One paper published</li> <li>• One PhD graduated</li> <li>• One manuscript in preparation</li> </ul>                                                                                                                                                                     |
| 2. Examine conflicts and collaborations between resource users in relation to billfish species in the in the Mozambique Channel          |          | <ul style="list-style-type: none"> <li>• Redefined the focus to Kenya and recruited a new Ph.D researcher</li> </ul>                                                                                                                                                                                              |
| <b>Objective 3: Evaluate the genetic stock structure of billfish family Istiophoridae using seasonal and spatial distribution data</b>   |          |                                                                                                                                                                                                                                                                                                                   |
| 1. Evaluate the genetic make-up, structure and zonation of selected flagship species                                                     |          | <ul style="list-style-type: none"> <li>• Optimisation protocol developed as part of BSc</li> <li>• One BSc graduate graduated</li> <li>• Genetic samples collected from Somalia, Kenya, Tanzania and Mozambique and shipped to Australia</li> <li>• for analysis Currently samples undergoing analysis</li> </ul> |
| <b>Objective 4: Socio-economic perspectives and governance</b>                                                                           |          |                                                                                                                                                                                                                                                                                                                   |
| 1. Determine billfish fishery profiles and socio-economics variation across sectors in the WIO                                           |          | <ul style="list-style-type: none"> <li>• Detailed socio-economic and catch data collected</li> <li>• 3 articles published (Potential for Conflicts in billfish fisheries in Kenya; Socio-economic perspectives of</li> </ul>                                                                                      |

|                                                                                                                                                    |  |                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                    |  | <p>billfish fisheries in Kenya; Competitive interactions between recreational and artisanal billfish fisheries in Kenya)</p> <ul style="list-style-type: none"> <li>• Several manuscripts under review</li> </ul>                                                                                           |
| 2. Road map for value chain                                                                                                                        |  | <ul style="list-style-type: none"> <li>• Manuscript under development</li> <li>• Master's student in progress</li> </ul>                                                                                                                                                                                    |
| 3. Evaluate multi-sectoral fishers' perceptions on billfish resources use, management and governance in the WIO                                    |  | <ul style="list-style-type: none"> <li>• One paper accepted</li> <li>• PhD in progress</li> </ul>                                                                                                                                                                                                           |
| 4. Determine effects of subsidies on billfish fisheries and the need for consensus on regional governance in the Western Indian Ocean (WIO) region |  | <ul style="list-style-type: none"> <li>• Manuscript under development</li> <li>• Master's student in progress</li> </ul>                                                                                                                                                                                    |
| <b>Objective 5: Dissemination of outputs and outcomes (please refer to table 1)</b>                                                                |  |                                                                                                                                                                                                                                                                                                             |
| 1. Annual Report writing                                                                                                                           |  | <ul style="list-style-type: none"> <li>• 2020, 2021 and 2022 reports produced</li> <li>• Presentation prepared and delivered in the WIOMSA-MASMA Grantees meeting</li> </ul>                                                                                                                                |
| 2. Writing of dissemination material                                                                                                               |  | <ul style="list-style-type: none"> <li>• Interactive website</li> <li>• Partnership with HCCS for communication and outreach</li> <li>• Presentations translated to Kiswahili, Somali and French</li> <li>• Billfish book under development</li> <li>• Billfish book for children conceptualized</li> </ul> |
| 3. Final project report + recommendations for Billfish fisheries in the WIO region                                                                 |  | <ul style="list-style-type: none"> <li>• Recommendations in publications, science communication media and in-person and virtual presentations</li> </ul>                                                                                                                                                    |

## 6.0 Overarching Lessons learnt

Lessons learnt from experiences in implementing a WIOMSA-MASMA funded regional project and understanding of the successes, failures and opportunities are important in improving future work. This final project report provides valuable insights on the outputs and outcomes with the aim of spurring further momentum around long-term investment in developing the research and leadership capacity of scientists, communities, institutions, and countries to tackle growing challenges in the marine environment.

Nonetheless, we recognize that this work could not have been achieved single-handedly by just the project team. We greatly thank our diverse collaborators, supporters, institutions, and platforms for challenging us to deliver our best through these 3 years; allowing us to succeed, fail and rise to seize the opportunities.

We summarize some of the key lessons as follows:

- **Commitment to research on highly migratory species should be long-term:** The ability to do this work at the scale of WIOMSA-MASMA funding inspired the need for long-term interventions. While the project team was able to leverage additional funding, we recognize and understand that such level of work and success cannot be achieved in typical project cycle and requires continuation.
- **Bringing stakeholders together is essential:** Successfully delivering a WIOMSA-MASMA project requires mobilizing stakeholders at different scales and engaging them in various dimensions of the work. The project's ability to bring collaborators at national, regional and global level was key in the outreach and higher coverage of a region as well the data collection process and publication.
  - Working at national, regional and global level allowed us to bring together a wide range of partners from the private sector, national and local government, local communities and associations, academic institutions, and the media, whom we engaged at different levels. The involvement of resource users in research also promotes a bottom-up approach to the co-management of billfish which compliments the current regional and national efforts that have largely focused on commercial fisheries.
- **Local level research:** Given the diversity of countries in the WIO region, it was important to promote the role of national institutions, ranging from academic, governmental, and research organizations to strengthen the capacity to deliver at multiple scales. Several local level collaborations were established or strengthened in support of billfish research which saw work gain more traction and publicity.
- **Regional research can take several pathways:** As much as the regional project had set goal and objectives, it was important for each country to deliver at a scale that addressed their needs and priorities. For example, in Somalia there was need to explore available information about billfish and create awareness regarding each of the species through

the Project Kalluun Series with 4 universities. This was different in South Africa and Kenya where we had existing historical and current data and some level of awareness about billfish fisheries, especially among recreational and sport fisheries.

- **Enhancing Capacity Development is key to long-term expertise and leadership:** The uniqueness of BILLFISH-WIO was its ability to bring students studying at different degree levels to share and advance much needed expertise and leadership for emerging and continuing researchers. Advancing the capacity for marine research is essential if want to improve the historical, current, and future understanding of our resources.
- **Engagement starts with communication:** The regionality of BILLFISH-WIO as a WIOMSA funded initiative meant that we had to accommodate the different languages. As such, our project materials were translated in Somalia, Kiswahili, Portuguese, and French to minimize language barriers. We also had to work with translators in our meetings to ensure inclusivity and equity in participation.

## 7.0 Appendix A: Screenshot image and links to published papers

### Appendix 1: Screenshot of publication on the [Status and challenges for sustainable billfish fisheries in the Western Indian Ocean](#)



## Appendix 2: Screenshot of publication on the [Challenges and Opportunities for sustainable development and management of marine recreational and sport fisheries in the Western Indian Ocean](#)

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Challenges and opportunities for sustainable development and management of marine recreational and sport fisheries in the Western Indian Ocean

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**ARTICLE INFO**

**Keywords:**  
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**ABSTRACT**

In the Western Indian Ocean (WIO) region, information and data on marine recreational fisheries (MRF) is lacking, which undermines efforts towards their sustainable development. Our paper reviews the challenges and opportunities for sustainably developing marine recreational fisheries in the WIO. We identified several challenges that are discussed in two broad categories: (i) governance and (ii) socio-cultural and economic. We also show that addressing these challenges requires a holistic understanding of the socio-ecological complexities and the multi-scale nature of WIO MRF. Realizing the potential for sustainable development of this sector calls for the involvement of coastal communities in the sharing of benefits and decision-making. Further, coordinated efforts between the multi-government agencies and non-governmental organizations is critical for integrating recreational fisheries into local and national agendas. We conclude that the sustainable development of MRF in the WIO region is possible. Still, such growth will be dependent upon the sustained capacity building of coastal communities and indigenous fishers, collaboration from stakeholders, and the long-term sustainability of the resource.

**1. Introduction**

In times of growing interest in the sustainable development and management of fisheries in the Western Indian Ocean (WIO) region, limited studies actively explore the definitions, challenges and opportunities surrounding marine recreational fishing (MRF). Recreational fishing, commonly referred to as sportfishing or angling, is defined as fishing primarily conducted by an individual largely for leisure, and the catch may constitute a source of nutrition to some extent but is not meant to be sold [1–4]. In the WIO region, this activity is mostly carried out using rod and reel with hook and line to catch fish and has a long history in places such as Kenya and South Africa [5–8] and can be a significant contributor to coastal economies [9,10]. However, in common with the global situation [11], MRF in many WIO countries remain understudied and under-represented in conventional discussions on the role of fisheries in development agendas and sustainable fisheries management, with the exception of South Africa [12–15] and Kenya to some extent [6,16–18,66,116].

Through this perspective article, we seek to add to the ongoing discussion on the role of MRF in development agendas (e.g., [19,20]), by focusing on the WIO with emphasis on selected countries. The objectives of this paper are to: examine the challenges facing MRF in the quest for their sustainable development and management; and discuss the opportunities that MRF present in the discourse around sustainability and future of fisheries in the WIO.

The WIO region is home to diverse fish species supporting a multitude of fisheries resource user groups including small-scale, industrial and recreational fisheries sectors [21,22]. Several million people across the WIO region depend on marine fisheries resources as a source of food and for socio-cultural and economic well-being [23–25], yet most

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### Appendix 3: Screenshot of the publication on [Characterizing competitive interactions between recreational and artisanal billfish fisheries in Kenya](#)

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## Ocean safaris or food: characterizing competitive interactions between recreational and artisanal billfish fisheries on the coast of Kenya

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ARTICLE INFO

**Keywords:**  
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ABSTRACT

Users of marine recreational and artisanal fisheries share a great interest in common resources, driving potential competitive interactions. In the Western Indian Ocean (WIO), limited information exists about these fisheries in particular for billfish species. The importance of billfish as a highly sought-after game fish species in recreational fishing, a source of food and income for artisanal fishers, and their ability to transverse various national jurisdictions as a shared resource make it necessary to evaluate sectoral interactions. Herein, we ask the question: what is the nature of these interactions in Kenyan waters?

We developed criteria for inferring competitive interactions based on time, space, and resource use and using billfish landings data collected through the creel survey, fishery-dependent sampling, and tagging. Results from tag recaptures show that both fishing sectors are capturing the same billfish resource, with a dominance of sailfin landings. We found no significant difference in the average landings between artisanal and recreational sectors, indicating equal demand for the billfish resource in terms of target species, geographic distribution, and seasonality. Therefore, our results suggest competitive interactions between the recreational and artisanal sectors, which have significant implications for management and socio-economic benefits for coastal communities.

1. Introduction

Fisheries resources are often exploited by multiple user groups, including large-scale industrial, artisanal, and recreational fishers, each with varying resource needs. Balancing the disparate demands for resources, objectives, and values of these different fishery users, which range from subsistence to recreation, requires the development of management decisions that address such issues (Girardin et al., 2015; Beill, 2014; de Castro and Begossi, 1996). The nature of the limited resources and the spatial and temporal overlap between sectors may lead to competition between the different user groups (Kadagi et al., 2020; Babali et al., 2018; Barnes et al., 2016; Pawson et al., 2008). A failure to identify and characterize competition among fishery user groups can have negative implications on food and socio-economic security, result in cultural loss of fishing identity, and inhibit effective governance resulting in conflicts due to differences in resource use needs.

Competitive interactions among fishers are a common feature in

fisheries. They can be inferred from the distribution of fishing vessels, fishing effort, catch rates, and target species (Barnes et al., 2016; Sys et al., 2016; Girardin et al., 2015). However, existing literature that seeks to characterize interactions among fishing sectors has primarily focused on specific features that cumulatively lead to competition rather than using set criteria to verify that these interactions are indeed competitive (Islam and Berkes, 2016; Dubois and Zografos, 2012; Bundy and Pauly, 2001; Kearney, 2001). One problem highlighted in several studies is that direct evidence for competitive interactions among fishers is complex and scarce (Gaichas et al., 2016; Marta et al., 2001). This is due to the general lack of empirical data and criteria to infer the occurrence of competition among fisheries user groups (Sys et al., 2016; Link and Auster, 2013; Rijnsdorp et al., 2000).

When defining competitive interactions between species in ecosystems, ecologists have commonly used three dimensions of resource use and partitioning which include: (i) the type of resource, (ii) the degree of overlap in the habitat of the species and (iii) the period of activity (Garcia and Vendel, 2016; Finke and Snyder, 2008; Bhat and Bharti,

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## Appendix 4: Screenshot of the publication on [Perception towards governance of billfish resource use](#).

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# Perceptions towards governance of billfish resource use: The lens of artisanal fishers in Kenya

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Multiple fisher groups target billfish species, each with different motivations and experiences, which can influence the effectiveness and sustainability of governance approaches. However, limited studies underscore the perceptions of billfish resource users in defining and implementing governance in the Western Indian Ocean region. We conducted 211 semi-structured qualitative interviews between December 2020 and September 2021, to explore how artisanal fishers perceive the performance and sustainability of governance approaches in Kenya, with a focus on billfish. Our findings show that artisanal fishers have adequate knowledge of fishing laws and regulations, as well as governing institutions and their performance. Further, artisanal fishers had a positive attitude and support for fishing rules, managing institutions, and effectiveness of governance intervention. Specifically, the fishers rated Beach Management Units (BMUs) as highly effective in implementing fisheries rules, indicating the involvement of fishers in co-management of fisheries and tendency for governance success and sustainability. This highlights the need to strengthen and support BMUs as an effective governance tool in the co-management of fisheries. We draw attention to our first-time study of the contribution of artisanal billfish fishers to governance of shared fisheries resources. We show that involvement of resource users promotes a bottom-up approach to the co-management of billfish which complements the current regional and national efforts that have largely focused on commercial fisheries. Our research adds to the scientific body of knowledge on the importance of perceptions in the formation of natural resource governance interventions at varying scales, especially for transboundary species in data-poor areas.

**KEYWORDS**  
perceptions, billfish, governance, beach management unit (BMU), fisheries, theory of planned behavior, Oceanography and hydrology

## Appendix 5: Screenshot of the publication on [Environmental controls of billfish species in the Indian Ocean and implications for their management and conservation](#)

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### RESEARCH ARTICLE

Diversity and Distributions WILEY

## Environmental controls of billfish species in the Indian Ocean and implications for their management and conservation

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#### Abstract

**Background and aim:** Billfish are epipelagic marine predators facing increasing pressures such as overfishing and rising global temperatures. Overfishing is a major concern, as they are caught by industrial longline fishers targeting tuna. Billfish are targeted by multiple fishing sectors, which provides food, socio-economic and cultural benefits. To support effective billfish management and conservation, it is essential to understand their spatial distribution and the environmental factors that may influence it.

**Location:** The focus of this study is the Indian Ocean (IO), where there are gaps in understanding the interactions between fisheries and billfish distribution. Three of six billfish species are at risk from overfishing. Therefore, determining their distribution is crucial to their management and conservation.

**Methods:** Using Ocean Biogeographic Information System (OBIS) occurrence data, Indian Ocean Tuna Commission (IOTC) catch data, and environmental covariates, we applied species distribution models to investigate the spatial extent of the realized niches of six billfish species in the IO. We also determined the role and relative importance of environmental drivers. Moreover, we evaluated the association between species' spatial distribution and the fishing effort distribution.

**Results:** We found niche partitioning and overlap among the six species identified spatial distribution, with higher species richness in the northern region of the IO and off the East coast of Africa. Temperature, mixed layer depth and salinity were identified as the most important predictors of species distribution, with moderately warm and stable environments preferred by most billfish species. Areas with high species richness and high fishing effort overlap were primarily found in the Areas Beyond National Jurisdiction (ABNJ). In contrast, areas with high species diversity richness and low fishing effort were found mainly in the Exclusive Economic Zone (EEZ).

**Main conclusion:** Spatial overlap between fishing effort and billfish projected distribution suggests inadvertent fishing pressure on billfish populations as they are caught together with targeted tuna. Spatial distribution transcends maritime zones,

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Diversity and Distributions WILEY 1555

reinforcing a need to formulate effective management policies for marine areas beyond national jurisdictions.

Appendix 6: Screenshot of the publication on [Potential for Conflicts in recreational and artisanal billfish fisheries in Kenya](#)



Marine Policy  
Volume 117, July 2020, 103960



## Potential for conflicts in recreational and artisanal billfish fisheries on the coast of Kenya

N.I. Kadagi<sup>a</sup> , N. Wambiji<sup>b</sup> , M.E. Swisher<sup>c</sup>

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### Abstract

The Western Indian Ocean (WIO) region is home to several species of billfish that are important ecologically as top predators and as a source of local livelihoods both within and outside the country's borders, thus targeted by multiple resource user groups. However, little attention has been paid to the characteristics of recreational and artisanal billfish fishers, and the potential conflicts that may arise in shared fishery resources in the Western Indian Ocean. Our paper examines the characteristics of recreational and artisanal billfish resource users, particularly the factors that often can lead to potential conflicts. We conducted semi-structured interviews with a total of 130 recreational and artisanal fishers at two study sites along the Kenya coast. We identified three primary drivers of potential conflict: perception of billfish as an open access resource, the competing uses, and internal and external issues related to fisheries governance. Some potential conflicts including social, ecological, governance and economic conflicts are discussed. These findings provide key insights about the complexities of multiple resource user groups and governance in exacerbating fisheries conflicts in this resource system. The findings also highlight the need to develop strategies to decrease conflicts, such as fisheries co-management, in the light of multiple billfish resource user groups and the species' ability to traverse various transnational boundaries.

## Appendix B: Links to previous reports to WIOMSA

Appendix B1: [WIOMSA Annual Progress Report 2021](#) (See [link](#) for the detailed report)

### **Billfish Interactions, Livelihoods, and Linkages for Fisheries Sustainability in the Western Indian Ocean (BILLFISH-WIO)**

**Website:** <https://billfishwio.com>; **twitter:** @billfishwio

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**Countries covered:** Somalia, Kenya, Tanzania (including Zanzibar), Mozambique, Madagascar and South Africa.

**Implementing institutions:** African Billfish Foundation (ABF), Kenya Marine and Fisheries Research Institute (KMFRI), University of Dar es Salaam (UDSM), One Earth Future – Secure Fisheries, Oceanographic Research Institute (ORI), Tanzania Deep Sea Fisheries Authority (DSFA), Fisheries Research Institute of Mozambique (IIP)

**Prepared by:** Dr. Nelly Isigi Kadagi, Dr. Nina Wambiji and Ms. Sarah Ater

**Date of Submission:** 5<sup>th</sup> November 2021



Appendix B2: [WIOMSA Annual Progress Report 2020](#) (See [link](#) for the detailed report)

**Billfish Interactions, Livelihoods, and Linkages for Fisheries sustainability in the  
Western Indian Ocean  
(BILLFISH-WIO)**

<https://billfishwio.com/>

**Annual Progress Report for the period:** September 2019 – September 2020

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**Countries Covered:** Somalia, Kenya, Tanzania (including Zanzibar), Mozambique, Madagascar, South Africa

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